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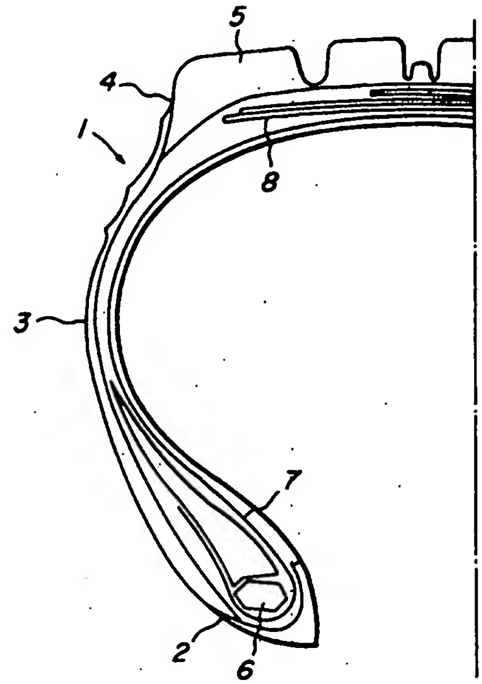
(54) **PNEUMATIC RADIAL TIRE.**

(57) A radial tire comprising a toroidal carcass (7) composed of steel cords arranged substantially in parallel to the meridional section of the tire and rubber coating the steel cords and belts (8) composed of steel cords disposed outside the crown portion of the carcass and inside a tread and rubber coating the steel cords. The carbon content and the filament tensile force of the steel cord at least in either of the carcass (7) or the belt (8) of the tire fall each within a predetermined range, the surfaces of the steel cords are plated with cobalt, and 100% modulus after vulcanizing the coating rubber is 20 kg/cm^2 or above. This tire can be reduced in weight and improved in resistances to separation and corrosion fatigue of the ply ends.

EP 0 481 080 A1

FIG. 1



TECHNICAL FIELD

This invention relates to a radial tire having considerably improved durable life by improving metal cords applied to reinforcements such as belt cord and carcass ply cord in the radial tire and coating rubber therefor.

BACKGROUND ART

In the tires using steel cords as a reinforcing material, separation at belt end (BES) and separation at carcass ply end (PES) are caused to make the retreading impossible and there may be caused a problem in the safeness. In order to prevent the occurrence of separation at the steel cord end, Japanese Utility Model laid open No. 61-206695 discloses, for example, an improving technique of steel cords wherein the bending rigidity of the steel cord is made large for the prevention of BES. However, such steel cords have a problem in the resistance to fretting fatigue, and also can not be said to be sufficient at the present when considering that the bending rigidity of the steel cord itself lowers due to the increase of the strength in the steel cord recently required for reducing the weight of the radial tire as a social need.

That is, there are caused problems such as lowering of resistance to bent end separation (resistance to BES), lowering of corrosion fatigue resistance in metal cord as a carcass ply material and the like due to the increase of the strength in the metal cord.

Therefore, it is required to develop a technique of improving not only the steel cord but also the combination of steel cord and rubber. Particularly, in order to prevent the separation failures, it is important to improve the coating rubber for the steel cord and rubber surrounding the cord end to conduct the control of crack growth in the rubber itself. In Japanese Patent laid open No. 62-273237 and No. 63-256636 are disclosed rubber compositions having an excellent resistance to crack growth, but the adhesion property to steel cord as a coating rubber is not disclosed at all, so that such a rubber composition is not suitable as a coating rubber.

In order to suppress BES and PES by using a means other than the use of the reinforcing material in the vicinity of the end portion, it is necessary to conduct the control of crack growth in rubber while maintaining the adhesion performance between cord and rubber at a level higher than the conventional one.

As a conventional method of adhering tire cords to rubber, it is general to be a direct adhesion method wherein the tire cord is subjected to a brass plating of copper and zinc alloy and then reacted with sulfur in rubber. In this case, it is attempted to increase the adhesion force by adding an organic cobalt salt such as cobalt naphthenate or the like to the coating rubber.

The technique of improving the plated steel cord to increase the adhesion force between cord and rubber is disclosed in Japanese Patent laid open No. 54-89939, No. 54-89940, No. 57-56110 and the like. Even in all cases, however, a slight amount of cobalt is only existent on the outermost surface of the cord due to thermal diffusion in the drawing after the plating, so that the adhesion action of cobalt to the cord surface is very small and there is a problem that the good adhesion is not obtained to rubber containing no organic cobalt salt. Particularly, the inventors have sufficiently examined the content of the above Japanese Patent laid open No. 57-56110 and confirmed that when a ternary alloy plated layer of cobalt was produced by the method described in this reference, the cobalt rich layer was not formed on the surface but diffused thereinto and hence the good adhesion was not indicated to rubber containing no organic cobalt salt.

The inventors have made studies with respect to steel cord reinforcement and coating rubber in radial tires for developing these tires capable of largely improving durable performances under the above circumstances, and found that the progress of rubber cracking is too fast in the conventional combination of brass plated cord and coating rubber and hence it is undesirably apt to cause BES and PES in the radial tire using such cords and rubber.

Particularly, there is a problem that BES is apt to be caused when using high-strength cords in which tensile strength TS (Kgf/mm^2) of each steel filament (wire) constituting the steel cord is represented by the following equations:

$TS \geq 281.60 + 288.75d$ $(0.1 \leq d < 0.2)$
$TS \geq 427.25 + 439.50d$ $(0.2 \leq d \leq 0.5)$

(wherein d is a diameter of the filament).

Furthermore, when such cords and rubber are applied to carcass ply cord and coating rubber in radial tire for truck and bus (TBR), radial tire for light truck (LSR) and the like, there have been found a problem that the corrosion fatigue resistance is lowered under severe use states, and a problem that the fracture

resistance at end of carcass ply (resistance to ply end separation) is apt to be lowered because cracks are apt to be caused from the turnup end of the carcass ply cord. Moreover, when high-strength cords having a tensile strength of filament of not less than 320 Kgf/mm^2 is used as a ply cord, the corrosion fatigue resistance is largely lowered.

It is, therefore, an object of the invention to provide an improving technique for radial tires capable of largely improving resistance to belt end separation (resistance to BES), resistance to carcass ply end (resistance to PES) and corrosion fatigue resistance.

DISCLOSURE OF INVENTION

The invention lies in a radial tire comprising a toroidal carcass composed of steel cords substantially arranged in parallel to a meridional section of the tire and a coating rubber therefor, and a belt composed of steel cords arranged outside of a crown portion of the carcass and inside a tread and a coating rubber therefor, characterized in that the steel cord in the belt

(1) is obtained by twisting a plurality of filaments having a carbon content of 0.75-0.90% by weight,
(2) satisfies the following relations as a tensile strength TS (Kgf/mm^2) at a diameter d of the filament:

$TS \geq 281.60 + 288.75d$ when $0.1 \leq d < 0.2$
$TS \geq 427.25 - 439.50d$ when $0.2 \leq d \leq 0.5$,

(3) and is provided at its surface with a cobalt plated layer,
and the coating rubber has a 100% modulus of not less than 20 Kgf/cm^2 after vulcanization.

Furthermore, in the radial tire of the above type according to the invention, the steel cord in the belt may be a steel single wire, and in this case the filament diameter is 0.2-0.7 mm, and the surface of the steel single wire is provided with a cobalt plated layer, and the coating rubber after vulcanization has a 100% modulus of not less than 20 Kgf/cm^2.

Moreover, in the radial tire of this type according to the invention, the steel cord of the carcass ply is obtained by twisting a plurality of filaments each

(1) having a carbon content of 0.75-0.90% by weight,
(2) having a tensile strength of filament of not less than 320 Kgf/mm^2,
(3) and being provided at its surface with a cobalt plated layer,
and the coating rubber has a 100% modulus of not less than 20 Kgf/cm^2 after vulcanization.

The twisting method of the filaments as the steel cord in the belt and the carcass according to the invention may be single construction, layer construction or strand construction. As the diameter d of the filament, it is preferably 0.15-0.25 mmØ in case of the belt and 0.15-0.25 mmØ in case of the carcass.

Further, such a steel filament can be rendered into a higher tensile strength by such a multi-stage drawing that the reduction area is 97.5% and the drawing number is increased by 3-4 times from the usual drawing with the use of a lubricant having a good drawability. In case of the belt, the relation between d and TS preferably satisfies the following equations:

$TS \geq 345 - 30d$ when $0.1 \leq d < 0.2$
$TS \geq 379 - 200d$ when $0.2 \leq d \leq 0.5$.

When using steel single wires as the steel cord for the belt according to the invention, it is practically favorable that the carbon content is within a range of 0.65-0.90% by weight, preferably 0.75-0.90% by weight.

In the invention, it is favorable that at least one of the carcass and the belt has a single construction of lxn structure (n is an integer of 2-6) by twisting 2-6 filaments and the filament diameter is 0.15-0.5 mm.

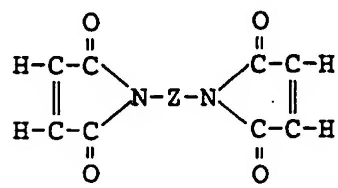
Preferably, in the single constructed steel cord of lxn structure, n is 2, or when n is 3-6, an elongation (P_1) when a load of 5.0 kg is applied to the steel cord is within a range of 0.2-1.2%.

As a coating method through cobalt plating, there may be an electroplating or various dry platings. Furthermore, the coating step may be carried out before or after the twisting step. The thickness of cobalt plated layer is preferably within a range of 0.05-0.40 μm in case of the electroplating, and within a range of 0.001-0.15 μm in case of the dry plating.

Moreover, anyone of iron as well as copper, zinc and brass applied to iron may be used as an underground for cobalt plating.

According to the invention, the coating rubber for the carcass or the belt is preferably a rubber

composition containing 0-0.1 part by weight as a cobalt metal of organic cobalt metal salt and 0.15-4.0 parts by weight of sulfur based on 100 parts by weight of rubber component. More preferably, the rubber composition contains 0.05-6.0 parts by weight of a bismaleimido compound represented by the following formula:



(wherein Z is an alkylene group, phenylene group, alkylphenylene group or a combination of two or more of these groups).

In the invention, why the carbon content of the filament in the twisted cord is within a range of 0.75-0.90% by weight is due to the fact that when it is less than 0.75% by weight, the sufficient filament tensile strength is hardly obtained, while when it exceeds 0.90% by weight, proeutectoid cementite is produced to enbrittle the filament and hence the use of the twisted cord becomes unsuitable as a tire cord.

Further, according to the invention, when the twisted cord is used in the belt, the filament tensile strength TS is required to satisfy the following equations:

$TS \geqq 281.60 + 288.75d$ when $0.1 \leqq d < 0.2$

$TS \geqq 427.25 - 439.50d$ when $0.2 \leqq d \leqq 0.5$.

This is due to the fact that when considering the large reduction of tire weight, the use of cords with a low tensile strength not satisfying the above equations does not provide a practical effect. And also, the reason why the relation is divided into the above two equations around $d + 0.2$ mm is due to the fact that the peak of the tensile strength is $d = 0.2$ mm in accordance with the easiness of the drawing.

In addition, the reason why the filament tensile strength is not less than 320 Kgf/mm^2 when the twisted cord is used in the carcass is due to the fact that when considering the large reduction of tire weight, the practical effect is not obtained at the tensile strength of less than 320 Kgf/mm^2.

Moreover, the upper limit of the filament tensile strength is about 450 Kgf/mm^2 from a viewpoint of the production workability.

In case of rubber penetrable cord of the single construction according to the invention, rubber penetrates into the inside of the cord, so that the adhesion property between cord and rubber inside the cord becomes very important in view of the tire durability.

In the single constructed steel cord of lx2 structure by twisting two filaments, the step of applying and forming cobalt layer to the surface of the filament may be carried out by wet process such as electroplating and the like, or dry plating process before and after the twisting step of the cord. This is due to the fact that even when the single constructed steel cords are subjected to a cobalt plating treatment, the full surface of the filament is coated with cobalt plated layer.

On the other hand, in the single constructed steel cords of lx3 to lx6 structures by twisting 3-6 filaments, the cobalt plated layer may be formed onto the surface of the filament inside the cord by wet process such as electroplating or the like, but such a formation becomes difficult in case of the dry plating process. Even in the wet process, however, there are existent technical production problems such as problem on tension control in a plating line, problem on formation amount and uniformity of plated layer and the like.

In the single twisted steel cord of lx3 to lx6 structure, therefore, when using the dry plating process, it is preferable that a cobalt plated layer is formed on the surfaces of the filaments after the drawing and then these filaments are twisted with each other, while when using the wet process such as electroplating or the like, the step of forming the cobalt plated layer may be carried out before and after the twisting step, but it is preferable to conduct the step of forming the cobalt plated layer before the twisting step.

The steel cord used for the reinforcement of the belt and/or the carcass ply according to the invention is preferable to be a single constructed steel cord of lxn (n is an integer of 2-6) and have a filament diameter of 0.15-0.5 mm considering the penetrability of rubber into the inside of the cord as mentioned above.

Furthermore, the reason why the elongation (P_1) of the steel cords having lx3 to lx6 structures when using 3-6 filaments is preferably within a range of 0.2-1.2% is due to the fact that when the elongation (P_1)

is less than 0.2%, the coating rubber hardly penetrates into the inside of the cord, while when it exceeds 1.2%, the tension becomes easily ununiform during the calendering operation for surrounding the steel cord with the coating rubber and hence the disturbance of cords in the tire occurs to easily cause the lowering of conformity and durability. Moreover, in case of the lx2 structure, the coating rubber well penetrates into the inside of the cord even when the twisting structure of the cord is not the single constructed rubber penetrable structure as mentioned above.

Next, the reason why the preferable amount of sulfur in the coating rubber is 0.5-4.0 parts by weight based on 100 parts by weight of rubber component is due to the fact that when it is less than 0.5 part by weight, sufficient crosslinking reaction or adhesion reaction does not occur, while when it exceeds 4 parts by weight, the effect of the invention on the improvement of the resistance to BES and resistance to PES is lost.

Furthermore, the reason why the preferable amount of the organic cobalt salt in the coating rubber is not more than 0.1 part by weight as a cobalt metal is due to the fact that when it exceeds 0.1 part by weight, the action of degrading the adhesion property is brought about and also the thermal aging of rubber is promoted to degrade the durability of rubber. It is preferably less than 0.05 part by weight.

And also, when the bismaleimido compound represented by the above formula is compounded for more improving the heat resistance of the coating rubber, the compounding amount is limited to a range of 0.5-6.0 parts by weight. When it is less than 0.05 part by weight, the effect of improving the resistance to BES is not obtained, while when it exceeds 6.0 parts by weight, the effect by increasing the amount can not be expected. It is preferably 0.05-3 parts by weight, more particularly 0.1-2.0 parts by weight.

In addition, the reason why the modulus of the coating rubber is limited to not less than 20 Kgf/cm^2 is due to the fact that when it is less than 20 Kgf/cm^2, the strain of the coating rubber against input to the belt and the carcass ply becomes too large and hence the effect of the invention on the improvement of the resistances to BES and PES is lost and there is caused a problem in the durability. Particularly, when it is applied to the belt of the radial tire for passenger car, the steering stability undesirably lowers.

Moreover, according to the invention, the reason why the preferable thickness of the cobalt plated layer through electroplating is within a range of 0.05-0.40 μm is due to the fact that when it is less than 0.05 μm, the uniform and stable plated film is not obtained and the underground may sometimes be exposed to unstabilize the adhesion to rubber, while when it exceeds 0.40 μm, the gauge of plated cobalt becomes undesirably thicker in view of the production efficiency and cost. Similarly, the reason why the preferable thickness of the cobalt plated layer through the dry plating process is within a range of 0.001-0.15 μm is due to the fact that when it is less than 0.001 μm, the plated layer is at a state of island-like crystal or network-like crystal and the stable adhesion to rubber is not obtained, while when it exceeds 0.15 μm, the productivity and cost becomes unfavorable and the adhesion property inversely lowers.

According to the invention, the organic cobalt salt included in the coating rubber for the improvement of adhesion force to the conventional cord coated at outermost surface with brass can be removed off from the coating rubber or reduced to a very slight amount by covering the surface of outermost layer of the steel cord with the cobalt plated layer, and consequently it is possible to obtain a rubber composition capable of controlling the deterioration of adhesion force with the lapse of time and thermal aging of strength at break, elongation and the like based on the addition of the organic cobalt salt.

Although a relatively large amount of sulfur (4-8 parts by weight) was used in the conventional technique for stably maintaining the heat-resistant adhesion property, according to the invention the amount of sulfur can be reduced to not more than 4 parts by weight, whereby the thermal aging of rubber due to the use of excessive amount of sulfur can be prevented and the resistance to crack growth is largely improved and further the corrosion fatigue resistance of the adjoining steel cord by the reduction of corrosive component can be improved.

In the tire according to the invention, therefore, not only the corrosion fatigue resistance, which comes into problem in the use of high-strength cord, can largely be improved, but also the resistance to ply end separation can considerably be improved.

Furthermore, when the bismaleimido compound is added to the coating rubber, not only the thermal aging of rubber is controlled, but also the modulus of rubber under a low deformation region can be improved, so that the resistance to BES under a low input can also be improved. Moreover, the use of the bismaleimido compound against the conventional brass plated cord usually degrades the adhesion property, so that the rubber composition containing the above compound can not be used as a coating rubber for tire cord in the conventional technique.

As mentioned above, in the radial tires according to the invention, the resistance to BES and the resistance to PES can be improved in all markets such as markets under thermally severe conditions apt to promote thermal aging, markets under thermally and mechanically gentle conditions.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a schematically partial section view of a radial tire for truck and bus (TBR) used in Example; and Fig. 2 is a schematically partial section view of a radial tire for passenger car (PSR) used in Example.

BEST MODE FOR CARRYING OUT THE INVENTION

Examples 1-10, Comparative Examples 1-7

The invention will be concretely described with reference to examples below.

As a tire for evaluation, there were used a radial tire 1 for truck and bus having a tire size of 1000 R20 as shown in Fig. 1 and a radial tire 10 for passenger car having a tire size of 185 SR14 as shown in Fig. 2. In the drawings, numeral 2 is a bead portion, numeral 3 a sidewall portion, numeral 4 a shoulder portion, numeral 5 a tread portion, numeral 6 a bead wire portion, numeral 7 a carcass ply and numeral 8 a belt portion.

In the radial tire for truck and bus, the cross belt layers had a structure of 3x0.20 mm+6 x 0.38 mm, while in the radial tire for passenger car, the cross belt layers had a structure of lx5x0.23 mm. The end count of cords in each tire was determined so as to provide the same strength as in control tires of Comparative Examples 1 and 4.

As a method of coating a filament with cobalt before the twisting of the filaments, there were used two processes of electroplating and dry plating (sputtering).

The electroplating was carried out under the following electroplating conditions after pretreatments of electrolytic degreasing and pickling. After the formation of cobalt coating, the filament was sufficiently washed through ultrasonic wave and then dried.

Electroplating conditions

- Bath composition
  - cobalt sulfate 330 g/ℓ
  - cobalt chloride 45 g/ℓ
  - boric acid 30 g/ℓ
  - sodium chloride 25 g/ℓ
- pH of bath : 4
- Bath temperature : 40·C
- Current density : 5 A/dm^2

On the other hand, the dry plating was carried out by using a magnetron sputtering device as follows. At first, the inside of the chamber was rendered into a vacuum degree of not more than 10-5 Torr and a slight amount of argon gas was flown thereinto to adjust the vacuum degree to 0.1 Torr, and then a surface of a test specimen was cleaned through high frequency glow discharge of 13.56 MHz for 5 minutes. After the cleaning, the high frequency glow discharge was stopped and a direct current of 600V was applied to a target of metal sample (cobalt), whereby the sputtering was carried out at a target current of 0.5A by argon plasma to form a cobalt coating.

As a coating rubber composition for the belt in the radial tire for truck and bus (TBR) and the radial tire for passenger car (PSR), there were used rubber compositions as shown in Tables 1 and 2, respectively. Furthermore, the same rubber composition as mentioned above was used in adjoining members at end portions of the cords. Moreover, the variable values in Table 1 were shown in Table 2.

Table 1 Rubber composition

Rubber composition	TBR (part by weight)	PSR (part by weight)
Natural rubber	80	80
Polyisoprene rubber	20	20
Carbon black	60	55
Zinc white	10	8
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.5	1.5
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	variable	variable
Sulfur	variable	variable
Organic cobalt salt (cobalt naphthenate)	variable	variable

The following evaluations for tire performances were carried out with respect to the above test tires.

Resistance to BES

It was evaluated by cutting the radial tire for passenger car after the actual running and measuring a crack length at belt end in the cross belt cord layer located toward tread side. That is, rubber was peeled off from cords of this belt layer to expose ends of cords, and the length of crack produced along the cord was measured by means of vernier calipers. The property was indicated by an index on the basis that the tires of Comparative Examples 1 and 4 were 100. The larger the index value, the better the resistance to BES.

Effect of reducing weight

The steel cords used in the test tire were embedded in the coating rubber for the belt to form a belt treat composite. In this case, the number of cords in each test treat was changed so as to provide the same strength as in the belt treat composites of control tires of Comparative Examples 1 and 4, whereby the effect of reducing weight was indicated as a weight of steel cords used per tire by an index on the basis that the control tires of Comparative Examples 1 and 4 were 100. The smaller the index value, the better the effect of reducing weight.

The results of performance evaluations with respect to the above test tires are shown in Table 2.

Moreover, the underground for cobalt plating in the above examples was iron plated with brass, but even when using iron alone as well as iron plated with copper or zinc as an underground, the evaluation results shown in Table 2 were unchangeable.

Table 2(a): Tires for truck and bus

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Example 1	Example 2	Example 3	Example 4	Example 5
Plating	process	electro-plating	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating	electro-plating
	outermost coating metal	brass	brass	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	-	-	0.15	0.04	0.15	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.5	2.5	2.5	-	-	-	-	0.3 *
	sulfur (Phr)	6.0	6.0	6.0	4.0	4.0	4.0	3.5	3.5
	vulcanization accelerator (Phr)	0.8	0.8	0.8	1.8	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm^2)	60	60	60	60	60	60	55	58
Cords	twisting structure	3 × 0.20 mm + 6 × 0.38 mm							
	C content in steel (wt%)	0.72	0.82	0.82	0.82	0.82	0.82	0.82	0.82
	tensile strength (Kgf/mm^2) core sheath	310 235	370 280	400 305	400 305	400 305	400 305	370 280	370 280
	cord tenacity (kg/cord)	179	215	233	233	233	233	215	215
	end count (cords/50 mm)	30.7	25.6	23.6	23.6	23.6	23.6	25.6	25.6
Evaluation	resistance to BES	100	96	93	130	135	128	130	125
	weight reducing effect	100	83	77	83	83	77	83	83

* 0.03 Phr as cobalt metal

Table 2(b): Tires for passenger car

		Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7	Example 6	Example 7	Example 8	Example 9	Example 10
Plating	process	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating	electro-plating
	outermost coating metal	brass	brass	brass	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	-	-	0.15	0.15	0.03	0.15	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	2.0	2.0	-	-	-	-	-	0.3 *
	vulcanization accelerator (Phr)	5.0	5.0	5.0	1.5	3.0	3.0	3.0	4.0	4.0
	sulfur (Phr)	0.8	0.8	0.8	0.5	1.8	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm^2)	44	44	44	18	45	45	45	52	55
Cords	twisting structure	1 × 5 × 0.23 mm								
	C content in steel (wt%)	0.72	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
	tensile strength (Kgf/mm^2) core	295	355	385	355	355	355	385	355	355
	cord tenacity (kg/cord)	59	71	77	71	71	71	77	71	71
	end count (cords/50 mm)	41.9	34.8	32.1	34.8	34.8	34.8	32.1	34.8	34.8
Evaluation	BES resistance to BES	100	99	97	97	130	130	125	120	115
	weight reducing effect	100	83	77	83	83	83	77	83	83

* 0.03 Phr as cobalt metal

Examples 11-14, Comparative Examples 8-9

As a tire for evaluation, there was used a radial tire for passenger car having a tire size of 165 SR13.

In the cross belt layers of the radial tire for passenger car was used single steel filaments each having a filament diameter of 0.50 mm. Moreover, the steel cord used had a carbon content of 0.82% by weight and the end count thereof was constant.

As a cobalt coating method for the filament, there were two processes of electroplating and dry plating (sputtering). These processes were the same as in the aforementioned examples.

As a coating rubber composition for the belt of the radial tire for passenger car (PSR), there were used rubber compositions as shown in Tables 3 and 4. Furthermore, the same rubber composition as mentioned above was used in adjoining members at end portions of the cords. Moreover, the variable values in Table 3 were shown in Table 4.

Table 3: Rubber composition

Natural rubber	80 parts by weight
Polyisoprene rubber	20
Carbon black	55
Zinc white	8
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.5
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	variable
Sulfur	variable
Organic cobalt salt (cobalt naphthenate)	variable

The resistance to BES was evaluated with respect to the above test tires in the same manner as in Example 1.

In this case, the property was indicated by an index on the basis that the tire of Comparative Example 8 was 100. The larger the index value, the better the resistance to BES.

The results of performance evaluation with respect to the test tires are shown in Table 4.

Moreover, the underground for cobalt plating in the above examples was iron plated with brass, but even when using iron alone as well as iron plated with copper or zinc as an underground, the evaluation results shown in Table 4 were unchangeable.

Table 4

		Comparative Example 8	Comparative Example 9	Example 11	Example 12	Example 13	Example 14
Plating	process	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	0.15	0.15	0.03	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	-	-	-	-	0.3 *
	sulfur (Phr)	5.0	1.5	3.0	3.0	4.0	4.0
	vulcanization accelerator (Phr)	0.8	0.5	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm²)	44	18	45	45	52	55
Tire performance: resistance to BES		100	97	140	138	135	135

* 0.03 Phr as cobalt metal (wt%)

Examples 15-21, Comparative Examples 10-14

As a tire for evaluation, there was used a radial tire for truck and bus (TBR) having a tire size of 11/70 R22.5, in which two kinds of compact cord of 3+9x0.20 mm+1 (same twisting direction) and steel cord of lx5x0.25 mm were arranged at an angle of 90° with respect to the circumferential direction of the tire as a carcass ply cord structure and the end count was determined so as to meet with the casing strength of the

control tire (Comparative Examples 10 and 14 shown in Table 6).

As a coating rubber composition for the carcass ply constituting the above tire, there were used rubber compositions shown in Table 5 and 6. Furthermore, the same composition was applied to adjoining members at ply cord ends.

Table 5: Rubber composition

Rubber composition	(parts by weight)
Natural rubber	80
Polyisoprene rubber	20
Carbon black	50
Zinc white	8
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.4
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	variable
Sulfur	variable
Organic cobalt salt (cobalt naphthenate)	variable

Moreover, two processes of electroplating and dry plating (sputtering process) were used as a plating method in the same manner as in the aforementioned examples.

The performances were evaluated with respect to the above test tires.

Resistance to CBU

Tires using the above steel cords in the carcass ply were prepared and mounted onto a rim, during which about 300 cc of water was incorporated into a space between inner liner and tube in the tire. The life (running distance) till the occurrence of cord breaking-up failure (CNU) was measured by a drum test of each test tire and indicated by an index on the basis that the control tire of Comparative Example 10 was 100. The larger the index value, the better the resistance to CBU.

Resistance to PES

The resistance to carcass ply end separation was evaluated by buffing the tread rubber of the test tire and at a state of causing no trouble of belt layer due to heat generation. Concretely, the test tire was rotated on a drum under conditions that a load was JIS 200%, a speed was 60 km/hr and an internal pressure was 8.25 Kgf/mm^2, during which a drum running distance of the test tire when separation at the end of carcass ply cord was caused to generate large vibration was measured and indicated by an index on the basis that the control tire of Comparative Example 10 was 100. The larger the index value, the better the resistance to carcass ply end separation.

Effect of reducing weight

The steel cords used in the test tire were embedded in the coating rubber for the carcass to form a ply treat composite. In this case, the number of cords in each test treat was changed so as to provide the same strength as in the ply treat composites of control tires of Comparative Example 10, whereby the effect of

reducing weight was indicated as a weight of steel cords used per tire by an index on the basis that the control tires of Comparative Example 10 were 100. The smaller the index value, the better the effect of reducing weight.

The results of performance evaluations with respect to the above test tires are shown in Table 6.

Moreover, the underground for cobalt plating in the above examples was iron plated with brass, but even when using iron alone as well as iron plated with copper or zinc as an underground, the evaluation results shown in Table 6 were unchangeable.

Table 6(a)

		Comparative Example 10	Comparative Example 11	Comparative Example 12	Comparative Example 13	Example 15	Example 16
Plating	process	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	dry plating
	outermost coating metal	brass	brass	brass	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	-	-	0.15	0.20	0.04
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	2.0	2.0	-	-	-
	sulfur (Phr)	5.0	5.0	5.0	2.0	2.5	2.5
	vulcanization accelerator (Phr)	0.5	0.5	0.5	0.5	1.5	1.5
	100% modulus (Kgf/cm^2)	35	35	35	18	34	34
Cords	twisting structure	3 + 9 × 0.20 + 1					
	C content in steel (wt%)	0.72	0.82	0.82	0.82	0.82	0.82
	tensile strength (Kgf/mm^2)	315	380	410	380	380	380
	cord tenacity (kg/cord)	117	141	152	141	141	141
	end count (cords/50 mm)	31.3	26.0	24.1	26.0	26.0	26.0
	casing strength (kg/50 mm)	3662	3666	3663	3666	3666	3666
Evaluation	resistance to CBU	100	87	73	118	115	118
	resistance to carcass ply end separation	100	103	105	96	147	145
	weight reducing effect	100	83	77	83	83	83

* 0.03 Phr as cobalt metal

Table 6(b)

		Example 17	Example 18	Example 19	Compar-ative Example 14	Example 20	Example 21
Plating	process	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	dry plating
	outermost coating metal	cobalt	cobalt	cobalt	brass	cobalt	cobalt
	cobalt plated thickness (μm)	0.15	0.15	0.15	-	0.15	0.02
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	-	-	0.3 *	2.0	-	-
	sulfur (Phr)	2.5	3.0	3.0	5.0	2.5	2.5
	vulcanization accelerator (Phr)	1.5	1.5	1.5	0.5	1.5	1.5
	100% modulus (Kgf/cm^2)	34	38	40	35	34	34
Cords	twisting structure	3 + 9 × 0.20 + 1				1 × 5 × 0.25	
	C content in steel (wt%)	0.82	0.82	0.82	0.82	0.82	0.82
	tensile strength (Kgf/mm^2)	410	380	380	380	380	380
	cord tenacity (kg/cord)	152	141	141	91	91	91
	end count (cords/50 mm)	24.1	26.0	26.0	40.2	40.2	40.2
	casing strength (kg/50 mm)	3663	3666	3666	3658	3658	3658
Evalua-tion	resistance to CBU	104	109	114	185	205	205
	resistance to carcass ply end separation	150	140	138	97	140	135
	weight reducing effect	77	83	83	80	80	80

* 0.03 Phr as cobalt metal

Examples 22-37, Comparative Examples 15-22

As a tire for evaluation, there were used a radial tire for truck and bus having a tire size of 11/70 R22.5 and a radial tire for passenger car having a tire size of 185 SR14.

The carcass ply structure of the radial tire for truck and bus was a structure of lx5x0.25 mm, while structures of lx5x0.23 mm, lx2x0.30 mm and lx3x0.30 mm were used in the cross belt layers of the radial tire for passenger car. Moreover, all of steel cords used had a carbon content of 0.82% by weight and the end count was constant.

As a method of coating filament with cobalt before the twisting of filaments, there were used to processes of electroplating and dry plating (sputtering) in the same manner as in the aforementioned

examples.

As a coating rubber composition for the carcass ply of the radial tire for truck and bus (TBR) and a coating rubber composition for the belt of the radial tire for passenger car (PSR), there were used rubber compositions as shown in Tables 7-9, respectively. Furthermore, the same rubber composition was applied to adjoining members at ends of cords. Moreover, the variable value in Table 7 was shown in Tables 8 and 9.

Table 7: Rubber composition

Rubber composition	Belt for PSR	Carcass ply for TBR
Natural rubber	80 parts by weight	80
Polyisoprene rubber	20	20
Carbon black	55	50
Zinc white	8	8
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.5	1.4
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	variable	variable
Sulfur	variable	variable
Organic cobalt salt (cobalt naphthenate)	variable	variable

The resistance to BES and resistance to PES were evaluated with respect to the test tires in the same manner as previously mentioned.

The resistance to BES was indicated by an index on the basis that tires of Comparative Examples 15, 19 and 21 were 100, respectively. The larger the index value, the better the resistance to BES. Furthermore, the resistance to PES was indicated by an index on the basis that the control tire of Comparative Example 17 was 100. The larger the index value, the better the resistance to PES.

The results of performance evaluations with respect to the test tires are shown in Table 8 and 9.

Moreover, the underground for cobalt plating in the above examples was iron plated with brass, but even when using iron alone as well as iron plated with copper or zinc as an underground, the evaluation results shown in Tables 8 and 9 were unchangeable.

Table 8(a)

		Comparative Example 15	Comparative Example 16	Example 22	Example 23	Example 24	Example 25
Kind of tire		radial tire for passenger car					
Plating	process	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	0.15	0.15	0.03	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	-	-	-	-	0.3 *
	sulfur (Phr)	5.0	1.5	3.0	3.0	4.0	4.0
	vulcanization accelerator (Phr)	0.8	0.5	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm^2)	44	18	45	45	52	55
Cords	twisting structure	1 × 5 × 0.23 mm					
	elongation (P_1)%, (load of 5.0 kg/cord)	0.65	0.65	0.65	0.65	0.65	0.65
Tire performances	resistance to BES	100	98	140	138	132	128
	resistance to PES	-	-	-	-	-	-

* 0.03 Phr as cobalt metal (wt%)

Table 8(b)

		Comparative Example 17	Comparative Example 18	Example 26	Example 27	Example 28	Example 29
Kind of tire		radial tire for truck and bus					
Plating	process	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	0.15	0.15	0.02	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	-	-	-	-	0.3 *
	sulfur (Phr)	5.0	2.0	2.5	2.5	3.0	3.0
	vulcanization accelerator (Phr)	0.5	0.5	1.5	1.5	1.5	1.5
	100% modulus (Kgf/cm^2)	35	18	34	34	38	40
Cords	twisting structure	1 × 5 × 0.25 mm					
	elongation (P_1)%, (load of 5.0 kg/cord)	0.63	0.63	0.63	0.63	0.63	0.63
Tire performances	resistance to BES	-	-	-	-	-	-
	resistance to PES	100	97	158	155	145	139

* 0.03 Phr as cobalt metal (wt%)

Table 9(a)

		Comparative Example 19	Comparative Example 20	Example 30	Example 31	Example 32	Example 33
Kind of tire		radial tire for passenger car					
Plating	process	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	0.15	0.15	0.03	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	-	-	-	-	0.3 *
	sulfur (Phr)	5.0	1.5	3.0	3.0	4.0	4.0
	vulcanization accelerator (Phr)	0.8	0.5	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm^2)	44	18	45	45	52	55
twisting structure		1 × 2 × 0.30 mm					
Tire performance: resistance to BES		100	98	140	140	135	130

* 0.03 Phr as cobalt metal (wt%)

Table 9(b)

		Comparative Example 21	Comparative Example 22	Example 34	Example 35	Example 36	Example 37
Kind of tire		radial tire for passenger car					
Plating	process	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal	brass	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)	-	0.15	0.15	0.02	0.15	0.15
Coating rubber	organic cobalt salt (cobalt naphthenate) (Phr)	2.0	-	-	-	-	0.3 *
	sulfur (Phr)	5.0	1.5	3.0	3.0	4.0	4.0
	vulcanization accelerator (Phr)	0.8	0.5	1.8	1.8	1.8	1.8
	100% modulus (Kgf/cm^2)	44	18	45	45	52	55
twisting structure		1 × 3 × 0.30 mm **					
Tire performance: resistance to BES		100	97	142	140	135	128

* 0.03 Phr as cobalt metal (wt%)

** Elongation (P_1) is 0.4%

Examples 38-44, Comparative Examples 23, 24 Conventional Example 1

In these examples, two processes of electroplating and dry plating (sputtering) were used as a plating method of cord in the same manner as in previous examples.

As a rubber composition embedding steel cords subjected to the above cobalt plating, there were used rubber compositions having a compounding recipe (part by weight) as shown in Tables 10 and 11 and prepared according to usual rubber compounding manner. Moreover, the variable value in Table 10 was shown in Table 11.

Table 10

Natural rubber	75 parts by weight
Polyisoprene rubber	25 "
Carbon black	60 "
Zinc white	8.0 "
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.5 "
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	1.0 "
Sulfur	variable
Organic cobalt salt (cobalt naphthenate)	variable
Bismaleimido compound	variable

The adhesion test between the steel cord and the rubber and the peeling test of rubber were carried out according to JIS-K-6301. The outline of the test method was described as follows.

Index of initial adhesion force and adhesion interface state

According to the peeling test of JIS-K-6301, steel cords of lx3x0.20 mm+6x0.38 mm were embedded in rubber at an end count of 26 cords/5 cm to form a strip specimen, which was cured at 145°C for 40 minutes to obtain test specimen.

Incisions were formed on the test specimen by means of a knife at a rate of 25 mm/min without causing rubber tear and then rubber piece was peeled off to measure a peeling strength. A value obtained by dividing an average value of the peeling strengths by a peeling number was an initial adhesion force and indicated by an index on the basis that Conventional Example 1 was 100. The larger the index value, the higher the initial adhesion force.

The adhesion interface state was evaluated by observing the peeled surface of the specimen after the completion of the peeling test and measuring the adhered state of rubber onto the cord surface as a mark point mentioned below:

1 0-20% rubber adhered state
2 20-40% rubber adhered state
3 40-60% rubber adhered state
4 60-80% rubber adhered state
5 80-100% rubber adhered state

The larger the mark point, the better the adhesion interface state.

As to the tensile strength after thermal aging, the tensile test was carried out at room temperature after the aging was carried out at 100°C for 24 hours by means of a gear type aging test machine according to an air heat aging test among aging tests of JIS-K-6301.6. The retention of tensile strength compared with tensile strength before the aging was measured and indicated by an index on the basis that Conventional Example 1 was 100. The larger the index value, the better the result.

The evaluation results are shown in Table 11.

Table 11

			Conventional Example 1	Comparative Example 23	Comparative Example 24	Example 38	Example 39	Example 40	Example 41	Example 42	Example 43	Example 44
Rubber composition	bismaleimido compound	phenylene bismaleimide	-	1.0	-	1.0	-	-	1.0	1.0	3.0	1.0
		hexamethylene bismaleimide	-	-	-	-	1.0	-	-	-	-	-
		ethylene bismaleimide	-	-	-	-	-	1.0	-	-	-	-
	sulfur		5.0	4.0	4.0	4.0	4.0	4.0	2.5	4.0	2.0	4.0
	organic cobalt salt (cobalt naphthenate)		2.0	2.0	-	-	-	-	-	-	-	0.3 *
Plating	process		electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal		brass	brass	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)		-	-	0.20	0.20	0.20	0.20	0.20	0.05	0.20	0.20
Measured values	index of initial adhesion force		100	30	101	104	100	102	101	103	100	100
	adhesion state		5	1	5	5	5	5	5	5	5	5
	retention of tensile strength after aging % (index)		53 (100)	63 (119)	71 (134)	80 (151)	79 (149)	78 (147)	86 (162)	80 (151)	83 (157)	78 (147)

* 0.03 Phr as cobalt metal

As seen from Table 11, in the composite of steel cord and rubber composition according to the invention, the resistance to thermal aging was largely improved without losing the initial adhesion property.

Examples 45-50, Comparative Examples 25, 26, Conventional Example 2

As a tire for evaluation, there was used radial tires for passenger car having tire sizes of 185 SR14 and P215/75 R15, and the performances thereof were evaluated.

In the cross belt layers of the radial tire for passenger car were used steel cords of lx5x0.23 mm structure.

Moreover, all of the steel cords used had a carbon content of 0.82% by weight and the end count thereof was constant.

The method of plating cobalt to the above steel cords was the same as described in the aforementioned examples. The coating rubber composition for the steel cord was prepared in the usual rubber compounding manner according to a compounding recipe (parts by weight) as shown in Tables 12 and 13. Moreover, the variable value in Table 12 was shown in Table 13.

Table 12

Natural rubber	80 parts by weight
Polyisoprene rubber	20 "
Carbon black	55 "
Zinc white	8 "
Antioxidant (made by Monsanto, trade name: Santoflex 13)	1.5 "
Vulcanization accelerator (made by Ouchi Shinko K.K., trade name: Noccelar DZ)	variable
Sulfur	variable
Organic cobalt salt (cobalt naphthenate)	variable
Bismaleimido compound	variable

The performance evaluations with respect to the above test tires were carried out as follows.

Resistance to BES

After the radial tire for passenger car having a tire size of P 215/75 R15 was actually run in tropic zone over a distance of 70,000km, it was cut to measure a crack length at an end of the cross belt layer located toward tread side. That is, rubber was peeled off from the cord of this belt layer to expose the cord end, and the length of crack produced along the cord was measured by means of vernier calipers and indicated by an index on the basis that Conventional Example 2 was 100.

After the radial tire for passenger car having a tire size of 185 SR14 was actually run in Japan over a distance of 50,000km, the length of crack produced along the belt cord was measured in the same manner as mentioned above and indicated by an index on the basis that Conventional Example 2 was 100.

The larger the index value, the better the resistance to BES.

The results of performance evaluation with respect to the test tires are shown in Table 13.

Moreover, the underground for cobalt plating in the above examples was iron plated with brass, but even when using iron alone as well as iron plated with copper or zinc as an underground, the evaluation results shown in Table 13 were unchangeable.

Table 13

			Conventional Example 2	Comparative Example 25	Comparative Example 26	Example 45	Example 46	Example 47	Example 48	Example 49	Example 50
Rubber composition	bismaleimido compound	phenylene bismaleimide	-	-	-	1.0	-	-	1.0	1.0	1.0
		hexamethylene bismaleimide	-	-	-	-	1.0	-	-	-	-
		ethylene bismaleimide	-	-	-	-	-	1.0	-	-	-
	sulfur		5.0	1.5	3.0	3.0	3.0	3.0	3.0	2.0	3.0
	organic cobalt salt (cobalt naphthenate)		2.0	-	-	-	-	-	-	-	0.3 *
	vulcanization accelerator		0.8	0.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	100% modulus (Kgf/cm^2)		44	18	44	52	50	51	52	45	54
Plating	process		electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	electro-plating	dry plating	electro-plating	electro-plating
	outermost coating metal		brass	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt	cobalt
	cobalt plated thickness (μm)		-	0.15	0.15	0.15	0.15	0.15	0.03	0.15	0.15
Resistance to BES of tire	running test in tropic zone		100	98	135	145	142	140	145	150	138
	running test in Japan		100	93	97	108	105	105	106	106	104

* 0.03 Phr as cobalt metal

As seen from the evaluation results of tire performance in Table 13 by both running tests in Japan and the Middle and Near East, in the radial tires according to the invention, the resistance to BES was largely improved.

INDUSTRIAL APPLICABILITY

As seen from the above examples, in the radial tires according to the invention, the tire weight can be reduced and the performances such as resistance to BES, resistance to PES and corrosion fatigue resistance are largely improved, so that the invention can considerably improve the durable life of the radial

tire such as radial tires for passenger car, radial tires for truck and bus, radial tires for light truck and the like.

Furthermore, the amount of sulfur contained in the coating rubber layer can be reduced in the invention, so that the reduction of sulfur in adjoining rubber members of the tire as well as the adjoining members themselves can be removed, and hence it is possible to produce new light-weight tires, which have never been attained in the conventional technique.

Claims

1. A pneumatic radial tire comprising a toroidal carcass composed of steel cords substantially arranged in parallel to a meridional section of the tire and a coating rubber therefor, and a belt composed of steel cords arranged outside of a crown portion of the carcass and inside a tread and a coating rubber therefor, characterized in that the steel cord in the belt
   (1) is obtained by twisting a plurality of filaments having a carbon content of 0.75-0.90% by weight,
   (2) satisfies the following relations as a tensile strength TS (Kgf/mm^2) at a diameter d (mm) of the filament:

   $TS \geq 281.60 + 288.75d$ when $0.1 \leq d < 0.2$
   $TS \geq 427.25 - 439.50d$ when $0.2 \leq d \leq 0.5$

   (3) and is provided at its surface with a cobalt plated layer,
   and the coating rubber has a 100% modulus of not less than 20 Kgf/cm^2 after vulcanization.

2. The pneumatic radial tire according to claim 1, wherein said filament has a diameter d of 0.15-0.40 mmØ.

3. The pneumatic radial tire according to claim 1, wherein said relation between d and TS satisfies the following equations:

   $TS \geq 345 - 30d$ when $0.1 \leq d < 0.2$
   $TS \geq 379 - 200d$ when $0.2 \leq d \leq 0.5$

4. A pneumatic radial tire comprising a toroidal carcass composed of steel cords substantially arranged in parallel to a meridional section of the tire and a coating rubber therefor, and a belt composed of steel cords arranged outside of a crown portion of the carcass and inside a tread and a coating rubber therefor, characterized in that said steel cord of the belt is a steel cord composed of single steel wire having a diameter of 0.2-0.7mm and provided at its surface with a cobalt plated layer, and
   the coating rubber after vulcanization has a 100% modulus of not less than 20 Kgf/cm^2.

5. A pneumatic radial tire comprising a toroidal carcass composed of steel cords substantially arranged in parallel to a meridional section of the tire and a coating rubber therefor, and a belt composed of steel cords arranged outside of a crown portion of the carcass and inside a tread and a coating rubber therefor, characterized in that the steel cord in the carcass is obtained by twisting a plurality of filaments each
   (1) having a carbon content of 0.75-0.90% by weight,
   (2) having a tensile strength of filament of not less than 320 Kgf/mm^2,
   (3) and being provided at its surface with a cobalt plated layer,
   and the coating rubber has a 100% modulus of not less than 20 Kgf/cm^2 after vulcanization.

6. The pneumatic radial tire according to claim 5, wherein said filament has a diameter d of 0.15-0.25 mmØ.

7. The pneumatic radial tire according to claim 1, 4 or 5, wherein said cobalt plated layer is formed by an electroplating.

8. The pneumatic radial tire according to claim 7, wherein said cobalt plated layer by said electroplating has a thickness of 0.05-0.40 μm.

9. The pneumatic radial tire according to claim 1, 4 or 5, wherein said cobalt plated layer is formed by a dry plating.

10. The pneumatic radial tire according to claim 9, wherein said cobalt plated layer by said dry plating has a thickness of 0.001-0.15 μm.

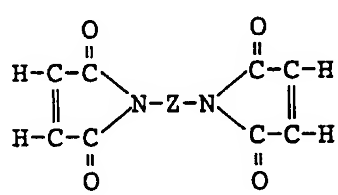
11. The pneumatic radial tire according to claim 1 or 5, wherein said steel cord is a single constructed steel cord of lxn structure (n is an integer of 2-6) by twisting 2-6 filaments and the filament diameter is 0.15-0.5mm.

12. The pneumatic radial tire according to claim 11, wherein n is 2 in said single constructed steel cord of lxn structure.

13. The pneumatic radial tire according to claim 11, wherein n is 3-6 in said single constructed steel cord and an elongation (P_1) when a load of 5.0 kg is applied to the steel cord is within a range of 0.2-1.2%.

14. The pneumatic radial tire according to claim 1, 4 or 5, wherein said coating rubber for the carcass or the belt is a rubber composition containing 0-0.1 part by weight as a cobalt metal of organic cobalt metal salt and 0.15-4.0 parts by weight of sulfur based on 100 parts by weight of rubber component.

15. The pneumatic radial tire according to claim 1, 4 or 5, wherein said coating rubber for the carcass or the belt is a rubber composition containing 0-0.1 part by weight as a cobalt metal of organic cobalt metal salt, 0.15-4.0 parts by weight of sulfur and 0.05-6.0 parts by weight of a bismaleimido compound represented by the following formula:



(wherein Z is an alkylene group, phenylene group, alkylphenylene group or a combination of two or more of these groups) based on 100 parts by weight of rubber component.

FIG_1

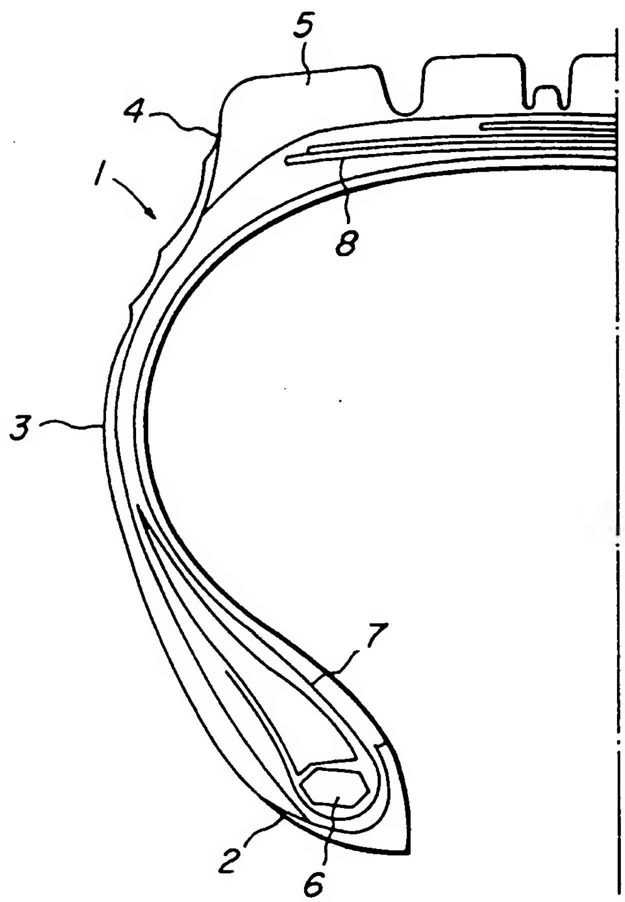
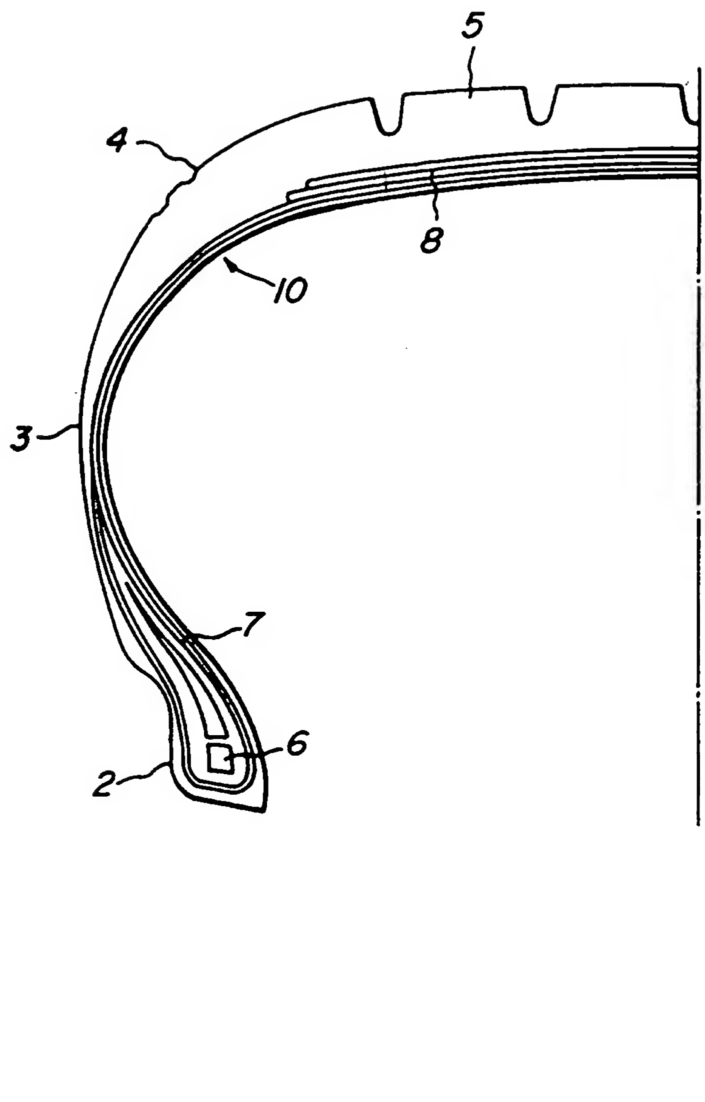


FIG_2



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/01694

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 B60C9/20, 9/08, D07B1/06

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B60C9/00, 9/08, 9/18, 9/20, D07B1/06

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1926 - 1990
Kokai Jitsuyo Shinan Koho 1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	JP, A, 2-53982 (N.V. Bekaert S.A.), February 22, 1990 (22. 02. 90), Tables 1, 2 (Family: none)	1, 2, 3, 5, 6, 11
A	JP, A, 1-201592 (Bridgestone Bekaert Steel Cord K.K.), August 14, 1989 (14. 08. 89), Table 1 (Family: none)	1, 2, 3, 5, 6, 11
A	JP, A, 1-239181 (Bridgestone Corp.), September 25, 1989 (25. 09. 89), Lines 5 to 12, lower left column, page 1, lines 14 to 18, lower right column, page 3, Table 1 (Family: none)	1, 2, 5, 6, 11, 13
A	JP, A, 64-31837 (Bridgestone Corp.), February 2, 1989 (02. 02. 89), Lines 5 to 13, lower left column, page 1 (Family: none)	1, 5, 7, 8, 14
A	JP, A, 1-278543 (Sanshin Kagaku Kogyo K.K.), November 8, 1989 (08. 11. 89),	15

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
March 13, 1991 (13. 03. 91)	March 25, 1991 (25. 03. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Lines 5, lower left column to
line 13, lower right column, page 1
(Family: none)

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers . . , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers .. .. , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.